CLAIMS

[1] An OFDM reception apparatus for receiving and demodulating an OFDM (Orthogonal Frequency Division Multiplexing) signal which transmits a pilot signal whose amplitude and phase are known, the apparatus comprising:

a channel estimation section for calculating a channel response before interpolation by performing computation between a frequency-domain OFDM signal obtained by Fourier-transforming the received OFDM signal and the pilot signal, performing interpolation with respect to the before-interpolation channel response using a plurality of filters having different characteristics from each other, and outputting a plurality of interpolated channel responses based on respective results of the interpolation obtained by the plurality of filters;

an equalization section for performing waveform equalization with respect to the frequency-domain OFDM signal based on the plurality of interpolated channel responses, and outputting a plurality of demodulated signals based on respective results of the waveform equalization corresponding to the plurality of interpolated channel responses;

a determination section for determining one having best quality from the plurality of demodulated signals, and outputting a result of the determination; and

a selection section for selecting and outputting one of the plurality of demodulated signals in accordance with the determination result.

[2] The OFDM reception apparatus of claim 1, wherein the channel estimation section comprises:

a channel response calculating section for calculating the before-interpolation channel response by performing computation between the frequency-domain OFDM signal and the pilot signal;

a symbol interpolating section for performing symbol-direction interpolation with respect to the before-interpolation channel response, and outputting a symbol-direction-

interpolated channel response; and

a carrier interpolating section having a plurality of carrier interpolating filters having different pass bands from each other, and for performing carrier-direction interpolation with respect to the symbol-direction-interpolated channel response using each of the plurality of carrier interpolating filters, and outputting a result of the carrier-direction interpolation as the plurality of interpolated channel responses.

[3] The OFDM reception apparatus of claim 1, wherein the channel estimation section comprises:

a channel response calculating section for calculating the before-interpolation channel response by performing computation between the frequency-domain OFDM signal and the pilot signal;

a symbol interpolating section having a plurality of filters having different pass bands from each other, and for performing symbol-direction interpolation with respect to the before-interpolation channel response using each of the plurality of filters, and outputting a result of the symbol-direction interpolation as a plurality of symbol-direction-interpolated channel responses; and

a plurality of carrier interpolating sections corresponding to the plurality of symbol-direction-interpolated channel responses, respectively,

wherein the plurality of carrier interpolating sections perform carrier-direction interpolation with respect to the respective corresponding symbol-direction-interpolated channel responses, and based on a result of the carrier-direction interpolation, outputting the plurality of interpolated channel responses.

[4] The OFDM reception apparatus of claim 3, wherein at least one of the plurality of carrier interpolating sections has a plurality of carrier interpolating filters having different pass bands from each other, and performs carrier-direction interpolation with respect to the

symbol-direction-interpolated channel response corresponding to the carrier interpolating section, using each of the plurality of carrier interpolating filter of the carrier interpolating section.

[5] The OFDM reception apparatus of claim 1, further comprising:

a plurality of delay sections corresponding to the plurality of demodulated signals output from the equalization section, respectively, and for delaying the respective corresponding demodulated signals and outputting the delayed demodulated signals to the selection section,

wherein each of the plurality of delay sections delays the corresponding demodulated signal so that timing with which the selection section obtains the determination result coincides with timing with which the selection section obtains the delayed demodulated signal.

[6] The OFDM reception apparatus of claim 1, wherein the determination section comprises:

a plurality of quality detecting sections corresponding to the plurality of demodulated signals obtained in the equalization section, respectively, and for obtaining quality values of the respective corresponding demodulated signals; and

a comparison section for performing determination based on the quality values obtained by the plurality of quality detecting sections,

wherein each of the plurality of quality detecting sections performs hard decision with respect to the corresponding demodulated signal to obtain a reference signal point, obtains a distance between the obtained reference signal point and a signal point before the hard decision for each carrier constituting the corresponding demodulated signal, and outputs a value corresponding to an average value obtained by averaging the obtained distances for a plurality of carriers constituting the corresponding demodulated signal.

[7] An OFDM reception apparatus for receiving and demodulating an OFDM signal which transmits a pilot signal whose amplitude and phase are known, the apparatus comprising:

a channel response calculating section for calculating a channel response before interpolation by performing computation between a frequency-domain OFDM signal obtained by Fourier-transforming the received OFDM signal and the pilot signal;

a symbol interpolating section having a plurality of filters having different pass bands from each other, and for performing symbol-direction interpolation with respect to the before-interpolation channel response using each of the plurality of filters, and outputting a result of the symbol-direction interpolation as a plurality of symbol-direction-interpolated channel responses;

an equalization section for performing waveform equalization with respect to the frequency-domain OFDM signal based on the plurality of symbol-direction-interpolated channel responses, and outputting a plurality of demodulated signals based on a result of the waveform equalization;

a determination section for determining one having best quality from the plurality of demodulated signals, and outputting a result of the determination;

a selection section for selecting and outputting one of the plurality of symbol-direction-interpolated channel responses in accordance with the determination result;

a carrier interpolating section for performing carrier-direction interpolation with respect to the channel response selected by the selection section, and outputting the carrier-direction-interpolated channel response; and

a division section for performing division with respect to the frequency-domain OFDM signal based on the carrier-direction-interpolated channel response, and outputting a result of the division as a demodulated signal.

[8] The OFDM reception apparatus of claim 7, further comprising:

a plurality of delay sections corresponding to the plurality of symbol-direction-interpolated channel responses, respectively, and for delaying the respective corresponding channel responses and outputting the delayed channel responses to the selection section,

wherein each of the plurality of delay sections delays the corresponding channel response so that timing with which the selection section obtains the determination result coincides with timing with which the selection section obtains the delayed channel response.

[9] The OFDM reception apparatus of claim 7, wherein the determination section comprises:

a plurality of quality detecting sections corresponding to the plurality of demodulated signals obtained in the equalization section, respectively, and for obtaining quality values of the respective corresponding demodulated signals; and

a comparison section for performing determination based on the quality values obtained by the plurality of quality detecting sections,

wherein each of the plurality of quality detecting sections performs hard decision with respect to the corresponding demodulated signal to obtain a reference signal point, obtains a distance between the obtained reference signal point and a signal point before the hard decision for each carrier constituting the corresponding demodulated signal, and outputs a value corresponding to an average value obtained by averaging the obtained distances for a plurality of carriers constituting the corresponding demodulated signal.

[10] An OFDM reception apparatus for receiving and demodulating an OFDM signal which transmits a pilot signal whose amplitude and phase are known, the apparatus comprising:

a channel response calculating section for calculating a channel response before

interpolation by performing computation between a frequency-domain OFDM signal obtained by Fourier-transforming the received OFDM signal and the pilot signal;

a noise removing section for removing noise in a predetermined frequency band from the before-interpolation channel response, and outputting a resultant noise-removed channel response;

a symbol interpolating section for performing symbol-direction interpolation with respect to the noise-removed channel response, and outputting a symbol-direction-interpolated channel response;

a carrier interpolating section having a plurality of carrier interpolating filters having different pass bands from each other, and for performing carrier-direction interpolation with respect to the symbol-direction-interpolated channel response using each of the plurality of carrier interpolating filters, and outputting a result of the carrier-direction interpolation as a plurality of carrier-direction-interpolated channel responses;

a difference detecting section for detecting a difference between the plurality of carrier-direction-interpolated channel responses in the predetermined frequency band or a portion thereof;

a selection section for selecting and outputting one of the plurality of carrier-direction-interpolated channel responses in accordance with a result of the detection of the difference detecting section; and

a division section for performing division with respect to the frequency-domain OFDM signal based on the channel response selected by the selection section, and outputting a result of the division as a demodulated signal.

[11] The OFDM reception apparatus of claim 10, wherein the noise removing section comprises:

an inverse Fourier transform section for subjecting an input channel response to inverse Fourier transform, and outputting a resultant impulse response;

a zero replacement section for replacing one having a magnitude less than a predetermined magnitude among the impulse responses with a 0 vector, and outputting a result of the replacement;

a Fourier transform section for subjecting an output of the zero replacement section to Fourier transform, and outputting a result of the Fourier transform; and

an end portion replacement section for outputting, of the output of the Fourier transform section, part within the predetermined frequency band, as it is, and replacing part within a frequency band other than the predetermined frequency band with the channel response input to the inverse Fourier transform section, and outputting a result of the replacement.

[12] An OFDM reception apparatus for receiving and demodulating an OFDM signal which transmits a pilot signal whose amplitude and phase are known, the apparatus comprising:

a channel response calculating section for calculating a channel response before interpolation by performing computation between a frequency-domain OFDM signal obtained by Fourier-transforming the received OFDM signal and the pilot signal;

a symbol interpolating section for performing symbol-direction interpolation with respect to the before-interpolation channel response, and outputting a symbol-direction-interpolated channel response;

a noise removing section for removing noise in a predetermined frequency band from the symbol-direction-interpolated channel response, and outputting a resultant noise-removed channel response;

a carrier interpolating section having a plurality of carrier interpolating filters having different pass bands from each other, and for performing carrier-direction interpolation with respect to the noisse-removed channel response using each of the plurality of carrier interpolating filters, and outputting a result of the carrier-direction

interpolation as a plurality of carrier-direction-interpolated channel responses;

a difference detecting section for detecting a difference between the plurality of carrier-direction-interpolated channel responses in the predetermined frequency band or a portion thereof;

a selection section for selecting and outputting one of the plurality of carrier-direction-interpolated channel responses in accordance with a result of the detection of the difference detecting section; and

a division section for performing division with respect to the frequency-domain OFDM signal based on the channel response selected by the selection section, and outputting a result of the division as a demodulated signal.

[13] The OFDM reception apparatus of claim 12, wherein the noise removing section comprises:

an inverse Fourier transform section for subjecting an input channel response to inverse Fourier transform, and outputting a resultant impulse response;

a zero replacement section for replacing one having a magnitude less than a predetermined magnitude among the impulse responses with a 0 vector, and outputting a result of the replacement;

a Fourier transform section for subjecting an output of the zero replacement section to Fourier transform and outputting a result of the Fourier transform; and

an end portion replacement section for outputting, of the output of the Fourier transform section, part within the predetermined frequency band, as it is, and replacing part within a frequency band other than the predetermined frequency band with the channel response input to the inverse Fourier transform section, and outputting a result of the replacement.

[14] An OFDM reception method for receiving and demodulating an OFDM signal

which transmits a pilot signal whose amplitude and phase are known, the method comprising:

a channel estimation step of calculating a channel response before interpolation by performing computation between a frequency-domain OFDM signal obtained by Fourier-transforming the received OFDM signal and the pilot signal, performing interpolation with respect to the before-interpolation channel response using a plurality of filters having different characteristics from each other, and obtaining a plurality of interpolated channel responses based on respective results of the interpolation obtained by the plurality of filters;

an equalization step of performing waveform equalization with respect to the frequency-domain OFDM signal based on the plurality of interpolated channel responses, and obtaining a plurality of demodulated signals based on respective results of the waveform equalization corresponding to the plurality of interpolated channel responses;

a determination step of determining one having best quality from the plurality of demodulated signals; and

a selection step of selecting one of the plurality of demodulated signals in accordance with a result of the determination.

[15] An OFDM reception method for receiving and demodulating an OFDM signal which transmits a pilot signal whose amplitude and phase are known, the method comprising:

a channel response calculating step of calculating a channel response before interpolation by performing computation between a frequency-domain OFDM signal obtained by Fourier-transforming the received OFDM signal and the pilot signal;

a symbol interpolating step of performing symbol-direction interpolation with respect to the before-interpolation channel response using each of a plurality of filters having different pass bands from each other, and obtaining a result of the symbol-direction

interpolation as a plurality of symbol-direction-interpolated channel responses;

an equalization step of performing waveform equalization with respect to the frequency-domain OFDM signal based on the plurality of symbol-direction-interpolated channel responses, and obtaining a plurality of demodulated signals based on a result of the waveform equalization;

a determination step of determining one having best quality from the plurality of demodulated signals;

a selection step of selecting one of the plurality of symbol-direction-interpolated channel responses in accordance with a result of the determination;

a carrier interpolating step of performing carrier-direction interpolation with respect to the channel response selected by the selection step, and obtaining the carrier-direction-interpolated channel response; and

a division step of performing division with respect to the frequency-domain OFDM signal based on the carrier-direction-interpolated channel response, and obtaining a result of the division as a demodulated signal.

[16] An OFDM reception method for receiving and demodulating an OFDM signal which transmits a pilot signal whose amplitude and phase are known, the method comprising:

a channel response calculating step of calculating a channel response before interpolation by performing computation between a frequency-domain OFDM signal obtained by Fourier-transforming the received OFDM signal and the pilot signal;

a noise removing step of removing noise in a predetermined frequency band from the before-interpolation channel response, and obtaining a resultant noise-removed channel response;

a symbol interpolating step of performing symbol-direction interpolation with respect to the noise-removed channel response, and obtaining a symbol-direction-

interpolated channel response;

a carrier interpolating step of performing carrier-direction interpolation with respect to the symbol-direction-interpolated channel response using each of a plurality of carrier interpolating filters having different pass bands from each other, and obtaining a result of the carrier-direction interpolation as a plurality of carrier-direction-interpolated channel responses;

a difference detecting step of detecting a difference between the plurality of carrier-direction-interpolated channel responses in the predetermined frequency band or a portion thereof;

a selection step of selecting one of the plurality of carrier-direction-interpolated channel responses in accordance with a result of the detection of the difference detecting step; and

a division step of performing division with respect to the frequency-domain OFDM signal based on the channel response selected by the selection step, and obtaining a result of the division as a demodulated signal.

[17] An OFDM reception method for receiving and demodulating an OFDM signal which transmits a pilot signal whose amplitude and phase are known, the method comprising:

a channel response calculating step of calculating a channel response before interpolation by performing computation between a frequency-domain OFDM signal obtained by Fourier-transforming the received OFDM signal and the pilot signal;

a symbol interpolating step of performing symbol-direction interpolation with respect to the before-interpolation channel response, and obtaining a symbol-direction-interpolated channel response;

a noise removing step of removing noise in a predetermined frequency band from the symbol-direction-interpolated channel response, and obtaining a resultant noise-

removed channel response;

a carrier interpolating step of performing carrier-direction interpolation with respect to the noisse-removed channel response using each of a plurality of carrier interpolating filters having different pass bands from each other, and obtaining a result of the carrier-direction interpolation as a plurality of carrier-direction-interpolated channel responses;

a difference detecting step of detecting a difference between the plurality of carrier-direction-interpolated channel responses in the predetermined frequency band or a portion thereof;

a selection step of selecting one of the plurality of carrier-direction-interpolated channel responses in accordance with a result of the detection of the difference detecting step; and

a division step of performing division with respect to the frequency-domain OFDM signal based on the channel response selected by the selection step, and obtaining a result of the division as a demodulated signal.